TETRACHLOROETHYLENE
(PERCHLOROETHYLENE)

Identified as a toxic air contaminant under California's air toxic program (AB 1807) in 1991.

CAS Registry Number: 127-18-4 $Cl_2C=CCl_2$

Molecular Formula: C_2Cl_4

Tetrachloroethylene is a chlorinated aliphatic hydrocarbon compound containing a double bond. At room temperature, tetrachloroethylene is a non-flammable, colorless, dense liquid with an ethereal odor. Although relatively insoluble in water, it is miscible in alcohol, ether, chloroform, and benzene (Merck, 1989). Tetrachloroethylene decomposes slowly in water to yield trichloroacetic and hydrochloric acids, and is oxidized by strong oxidizing agents (HSDB, 1995).

On November 21, 1996, the Air Resources Board (ARB) modified the Regulation for Reducing Volatile Organic Carbon Emissions from Consumer Products (section 94508, Title 17, California Code of Regulations) and the Regulation for Reducing Volatile Organic Compound Emissions from Aerosol Coating Products (section 94521, Title 17, California Code of Regulations) to exempt tetrachloroethylene (perchloroethylene) from the volatile organic compound definition. The ARB will continue to track emissions of tetrachloroethylene from consumer products and will be conducting an assessment under Assembly Bill 1807. If you have any questions regarding consumer products or the exemption of tetrachloroethylene, please call the Air Quality Measures Branch at (916) 445-6318.

Physical Properties of Tetrachloroethylene

Synonyms: perchloroethylene; tetrachloroethene; 1,1,2,2-tetrachloroethylene; ethylene tetrachloride; perc; PCE; Nema; Tetracap; Tetropil; Perclene; Ankilostin; Didakene

Molecular Weight:	165.85
Boiling Point:	121 ^oC at 760 mm Hg
Melting Point:	-22 ^oC
Vapor Pressure:	18.47 mm Hg at 25 ^oC
Vapor Density:	5.7 (air = 1)
Density/Specific Gravity:	1.6230 at 20/4 ^oC
Log Octanol/Water Partition Coefficient:	3.40
Conversion Factor:	1 ppb = 6.78 $\mu g/m^3$

(HSDB, 1995; Merck, 1989; Sax, 1989; U.S. EPA, 1994a)

SOURCES AND EMISSIONS

A. Sources

Tetrachloroethylene is a volatile organic hydrocarbon which is used as a solvent primarily in dry cleaning operations. Tetrachloroethylene is also used in degreasing operations, paints and coatings, adhesives, aerosols, specialty chemical production, printing inks, silicones, rug shampoos, and laboratory solvents (ARB, 1991b).

There are no producers of tetrachloroethylene in California (SRI, 1994). The primary stationary sources that have reported emissions of tetrachloroethylene in California are dry cleaning plants, aircraft parts and equipment manufacturers, and fabricated metal products manufacturers (ARB, 1997b).

Tetrachloroethylene was registered for use as a pesticide, however as of August 1, 1990, it is no longer registered for pesticidal use in California (DPR, 1996).

B. Emissions

The reported emissions of tetrachloroethylene from stationary sources in California are estimated to be at least 6.7 million pounds per year, based on data reported under the Air Toxics "Hot Spots" Program (AB 2588) (ARB, 1997b).

In 1993, the Air Resources Board (ARB) adopted an airborne toxic control measure (ATCM) that will reduce tetrachloroethylene emissions from dry cleaning operations. The ARB also adopted an environmental training regulation which establishes the procedures for the ARB to authorize individuals or organizations who want to offer the environmental training courses that are required by the ATCM. The ATCM addresses equipment requirements for existing and new facilities, good operating practices, and recordkeeping/reporting provisions resulting in anticipated emission reductions. The ATCM also requires each dry cleaning facility to have at least one person who has attended an ARB-approved environmental training course (ARB, 1993g).

C. Natural Occurrence

Tetrachloroethylene does not occur naturally in the environment (HSDB, 1995).

AMBIENT CONCENTRATIONS

Tetrachloroethylene is routinely monitored in California by the statewide ARB air toxics network. The network's mean concentration from January 1996 through December 1996 is estimated to be 0.128 micrograms per cubic meter ($\mu g/m^3$) or 0.019 parts per billion (ppb) (ARB, 1997c). When tetrachloroethylene was formally identified as a toxic air contaminant, the population-weighted annual concentration was estimated to be 2.5$\mu g/m^3$ or 0.37 ppb

(ARB, 1991b).

The United States Environmental Protection Agency (U.S. EPA) has compiled ambient concentration data from Columbus, Ohio during 1989 with a mean concentration of 1.59 $\mu g/m^3$, or 0.23 ppb, and the range varied from 0.21 to 40 $\mu g/m^3$ or 0.03 to 5.90 ppb. They also reported concentrations of tetrachloroethylene from 13 study areas during 1989 to 1991. The overall range of concentrations from these areas were from 0.69 to 104 $\mu g/m^3$ or 0.10 to 15.34 ppb with a mean concentration of 3.6 $\mu g/m^3$ or 0.53 ppb (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

Volatilization from dry cleaned garments is probably the largest source of tetrachloroethylene in indoor air. Brake quieters/cleaners, water repellents, and fabric finishes are also important sources of tetrachloroethylene (U.S. EPA, 1987d).

Results from both indoor and personal monitoring in California homes indicate that people are exposed frequently to tetrachloroethylene from indoor air. The level of exposure can vary among homes because different numbers and types of emission sources may be present in individual homes. In a large southern California study, the 24-hour average concentrations for residential indoor air ranged from 2.27 to 6.72 $\mu g/m^3$ while concurrent outdoor concentrations ranged from 1.74 to 4.41 $\mu g/m^3$. Using personal nighttime sampling data to approximate indoor air exposure, the 12-hour average indoor nighttime concentrations ranged from 5.45 to 8.56 $\mu g/m^3$ in comparison to the outdoor nighttime concentrations which ranged from 1.24 to 5.72 $\mu g/m^3$ (ARB, 1991b).

The most recent California study was conducted in Woodland, California in the spring of 1990. The average concentration of tetrachloroethylene of 124 indoor samples was 1.44 $\mu g/m^3$. Mean indoor concentrations from the Woodland study are approximately 2.7 times greater than the outdoor mean concentration of 0.53 $\mu g/m^3$ from the same study (Sheldon et al., 1992).

ATMOSPHERIC PERSISTENCE

The dominant tropospheric loss process for tetrachloroethylene is expected to be by reaction with the hydroxyl (OH) radical. The calculated half-life and lifetime for tetrachloroethylene due to gas-phase reaction with the OH radical are 2 months and 3 months, respectively (Atkinson, 1995). Both nitrate radical and ozone chemical reaction removal processes are too long to compete with the OH radical reaction. Tuazon et al. (1988) showed that the reaction of the OH radical with tetrachloroethylene generated chlorine atoms and that in the atmosphere the reaction forms phosgene and hydrogen chloride as well as other, as yet unidentified, products. Therefore, tetrachloroethylene is sufficiently persistent to be transported throughout an air basin before it is degraded (ARB, 1991b).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment (OEHHA) reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, tetrachloroethylene was the major contributor to the overall cancer risk in 43 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million and contributed to the total cancer risk in 79 of these risk assessments. Tetrachloroethylene also was the major contributor to the overall cancer risk in 7 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million, and contributed to a total cancer risk in 34 of these risk assessments (OEHHA, 1996a).

For non-cancer health effects, tetrachloroethylene contributed to the total hazard index in 35 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1, and presented an individual hazard index greater than 1 in 19 of these risk assessments. Tetrachloroethylene also contributed to the total hazard index in 23 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1, and presented an individual hazard index greater than 1 in 4 of these risk assessments (OEHHA, 1996b).

HEALTH EFFECTS

The probable route of human exposure to tetrachloroethylene is inhalation (ARB, 1991b).

Non-Cancer: Tetrachloroethylene vapors are irritating to the eyes and respiratory tract. It is a central nervous system depressant, and may also sensitize the myocardium to the arrhythmogenic effects of epinephrine. Workers have shown signs of liver toxicity following chronic exposure to tetrachloroethylene, as well as kidney dysfunction and neurological effects (ARB, 1991b; U.S. EPA, 1994a). Effects on the liver, kidney, and central nervous systems from chronic inhalation exposure to tetrachloroethylene have been reported in animal studies.

An acute non-cancer Reference Exposure Level (REL) of 6.8 x 10^3 $\mu g/m^3$ is listed in the California Air Pollution Control Officers Association (CAPCOA) Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for acute toxicity is the central nervous system. Also, a chronic REL of 35 $\mu g/m^3$ is listed in the CAPCOA Risk Assessment Guidelines. The toxicological endpoints considered for chronic toxicity are the kidney, liver, and gastrointestinal system (CAPCOA, 1993). The United States Environmental Protection Agency (U.S. EPA) has not established a Reference Concentration (RfC). The oral Reference Dose (RfD) for tetrachloroethylene is 0.01 milligrams per kilogram per day based on hepatotoxicity in mice and weight gain in rats (U.S. EPA, 1994a).

Epidemiological studies of women working in the dry cleaning industry showed some adverse reproductive effects, such as menstrual disorders and spontaneous abortions, but study design prevented significant conclusions (ARB, 1991b). Women exposed to drinking water contaminated with solvents including tetrachloroethylene, showed some evidence of birth defects. Inhalation exposure of pregnant rodents to 300 ppm tetrachloroethylene produced maternal toxicity and fetotoxicity manifested as developmental delays and altered performance in behavioral tests in the offspring of exposed mice and rats. However, tetrachloroethylene is

not considered to be a teratogen (ARB, 1991b).

Cancer: Epidemiological studies have provided some indication that the use of dry cleaning solvents, primarily tetrachloroethylene, poses an increased risk of cancer for exposed workers. However, investigators were unable to differentiate among exposures to various solvents, and other possible confounding factors, like smoking, were not evaluated. Tetrachloroethylene increased the incidence of hepatocellular tumors in laboratory mice after oral and inhalation exposure and mononuclear cell leukemia and kidney tumors in rats after inhalation (U.S. EPA, 1994a).

The U.S. EPA classified tetrachloroethylene as a Group B2/C: Probable human carcinogen on the basis of sufficient evidence for carcinogenicity in animals and inadequate evidence in humans (U.S. EPA, 1994a). The International Agency for Research on Cancer has classified tetrachloroethylene in Group 2A: Probable human carcinogen, based on sufficient evidence in animals and limited evidence in humans (IARC, 1995).

The State of California under AB 1807 and Proposition 65 listed tetrachloroethylene as a carcinogen and as a Toxic Air Contaminant (ARB, 1991b; CCR, 1996). The inhalation potency factor that has been used as a basis for regulatory action in California is 5.9×10^{-6} (microgram per cubic meter)$^{-1}$ (OEHHA, 1994). In other words, the potential excess cancer risk for a person exposed over a lifetime to 1 $\mu g/m^3$ of tetrachloroethylene is estimated to be no greater than 5.9 in 1 million. The oral potency factor that has been used as a basis for regulatory action in California is 5.1×10^{-2} (milligram per kilogram per day)$^{-1}$ (OEHHA, 1994).